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ELEC. & STRUCTURAL PROP. STUDY OF LAYERED DIELECTRIC & MAGNETIC

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Final Report

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14. ABSTRACT
In this work the magnetic and dielectric properties of ceramic-ceramic and ceramic-polymer composites with BiNbO4, SrBi2Nb2O9 (SBN), BaBi4Ti4O15 (BBT), Na2Nb4O11(NNO), Sr2CoNbO6 (SCN) and ferrites BaFe12O19 and Y3Fe5O12 (YIG) was studied for RF and microwave applications. New configurations of magneto-dielectric composites and blends structures for high frequency applications was done. A new method for the measurement of the temperature coefficient of resonant frequency (τf), is presented. The traditional method (based on the Courtney method) present some limitations of measuring the values of τf , for samples with high dielectric loss.

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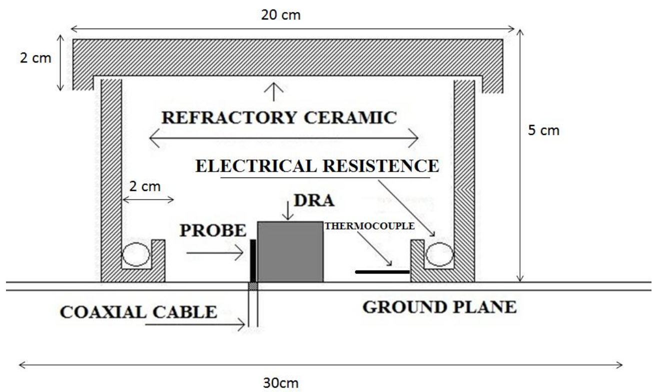
In this work the magnetic and dielectric properties of ceramic-ceramic and ceramic-polymer composites with $BiNbO_4$, $SrBi_2Nb_2O_9$ (SBN), $BaBi_4Ti_4O_{15}$ (BBT), $Na_2Nb_4O_{11}$(NNO), Sr_2CoNbO_6 (SCN) and ferrites $BaFe_{12}O_{19}$ and $Y_3Fe_5O_{12}$ (YIG) was studied for RF and microwave applications. New configurations of magneto-dielectric composites and blends structures for high frequency applications was done. The 0-3 type dielectric and magnetic composites with homogenously distributed ceramic inclusions was fabricated in a polymer matrix. Magnetic Yttrium Iron Garnet (YIG) and (SBN) powders were used to enhance the permittivity and permeability of the composites. This group of dielectric and magnetic phases was studied in the RF and microwave region. The microstructure, high frequency dielectric and magnetic properties of individual layers and 2-2 composites was investigated and measured.

A new method for the measurement of the temperature coefficient of resonant frequency (τ_f), is presented. The traditional method (based on the Courtney method) present some limitations of measuring the values of τ_f , for samples with high dielectric loss due to their inability to observe clearly the TE_{011} mode. The new experimental setup, to measure the τ_f value, is based on the variation of the temperature of the dominant mode of a dielectric resonator antenna (DRA).

The study of the thermal stability of magneto-dielectric composites is important for applications at the microwave band and in the millimeter and near millimeter region (100-300GHz) where the thermal stability of the resonators is fundamental.
In this project we are investigating experimentally and numerically this new method to measure the thermal stability of layered dielectric and magnetic composite structures for RF and Microwave Applications .

In the area of communication is important that the devices, responsible for transmitting/receiving data have its characteristics preserved in whatever temperature environment they are submitted. This new method for the measurement of the temperature coefficient of resonant frequency (τ_f), is presented. The traditional Courtney method, present some limitations of measuring the values of τ_f, for samples with high dielectric loss due to their inability to observe clearly the TE011 mode. The new experimental setup (figure below), to measure the τ_f value, is based on the variation of the temperature of the dominant mode of a dielectric resonator antenna.



Modified setup, for the measurement of τ_f
A new method to measure the microwave thermal stability coefficient τ_f

$$\tau_f = \frac{1}{f_i} * \frac{\Delta f}{\Delta T} * 10^6,$$

To use this new method a group of traditional materials were used to compare the traditional and new method

TABLE I. $TE_{01\delta}$, $HE_{11\delta}$ e $TM_{01\delta}$ modes and dielectric parameters of CTO, Al_2O_3, and BTNO dielectrics.

	$CaTiO_3$	Al_2O_3	BTNO
a (mm)	7.48	12.70	7.31
h (mm)	8.04	12.70	7.38
a(mm)/h(mm)	0.93	1	0.99
ε_R	92.25	9.80	63.68
tan δ	5.81×10^{-4}	1.11×10^{-4}	5.61×10^{-2}
$f_{monopole}$ (GHz) measured	1.888	3.089	2.439
$f_{HE11\delta}$ (GHz) calculated	1.837	3.147	2.328
$f_{TE01\delta}$ (GHz) calculated	1.830	3.201	2.288
$f_{TM01\delta}$ (GHz) calculated	2.695	4.527	3.357

Used samples in the measurements

The comparative between the two systems for measurement of τ_f values, show excellent agreement, as observed in Figure 4. In the Courtney procedure the obtained value is 621.10 ppm/^{o}C and compares to 624.32 ppm/^{o}C obtained in the DRA procedure. Both measurements exhibit the same linearity and angular coefficient (see TableII and Figure4).

The frequency evolution of the HE_{11d} mode with increasing temperature for DRA procedure is showed in Figure 5, where the HE_{11d} mode is isolated and well defined. The decrease in the return loss (in modulus) is associated to impedance matching variation due to volumetric expansion and the change in value of dielectric permittivity the DRA with temperature. The measurement of τ_f for the BTNO phase was not reported in the literature. We believe that the reason is the high dielectric loss, which almost do not allows to use the Courtney method. In this case, the resonances are too broad. Considering the Courtney geometry, the quality factor for TE_{011} mode is low, leading to a broad band. The monitoring of the resonant frequency shift with temperature is quite difficult with the enlargement of this band and a very poor mode visualization, see Figure7.
In the present proposed new method, the measurement of the τ_f for BTNO is quite satisfactory. The HE_{11d} mode is quite strong and well defined . The value of τ_f =-104.19 ppm/^{o}C (Table II) was obtained for the first time. The linearity for frequency shift with temperature increase is showed in Figure 9, where a good linear agreement of the frequency with temperature was obtained.

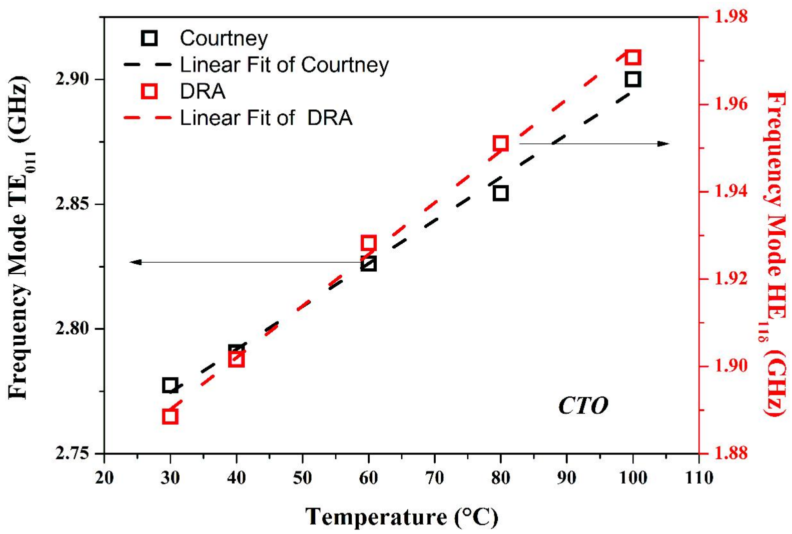


FIG. 4. Measurement of τ_f for a DRA based on CTO: □ alternative method ($HE_{11\delta}$) and ○ Courtney method (TE_{011}).

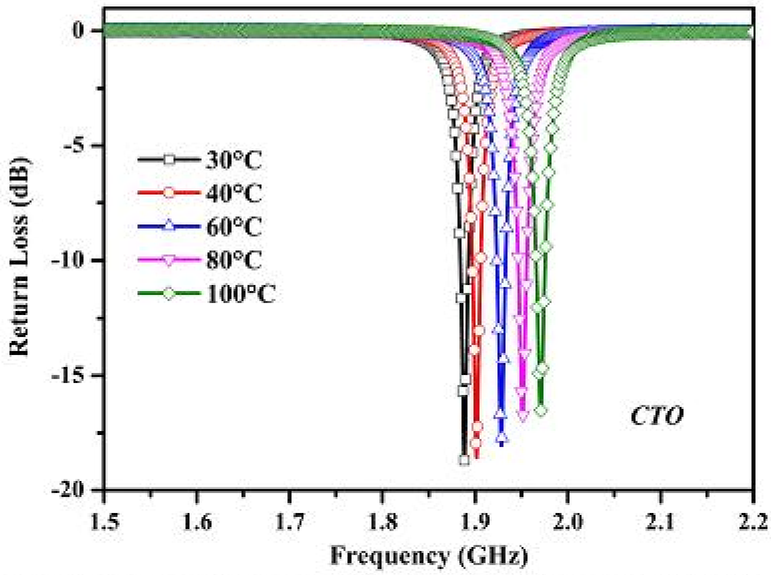


FIG. 5. Frequency variation of the $HE_{11\delta}$ mode for DRA based on CTO with increasing temperature.

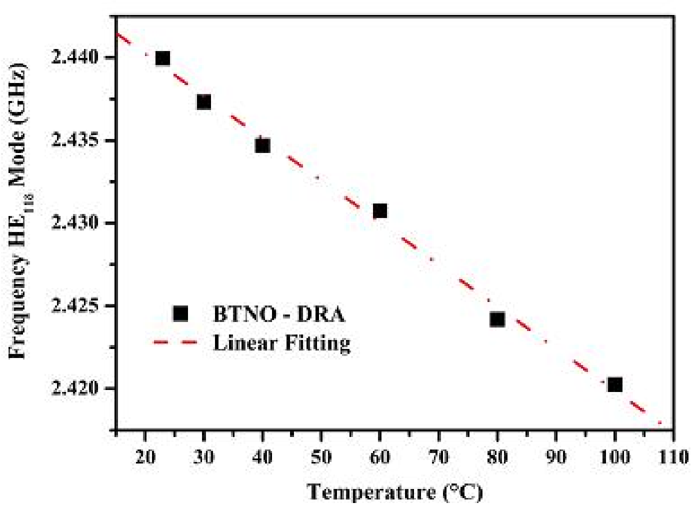


FIG. 9. Measurement of τ_f for a DRA based on BTNO by the alternative method ($HE_{11\delta}$).

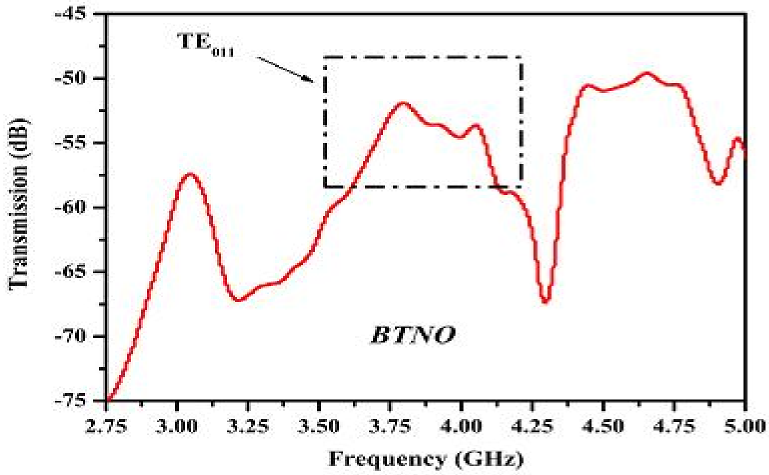


FIG. 7. Measurement of transmission by the Courtney method for the BTNO resonator.

TABLE II. Measurements of τ_f of CTO, Al_2O_3, and BTNO from Courtney and DRA methods.

	Method					
	Courtney method			Dielectric resonator antenna		
Ceramic	τ_f (ppm °C^{-1})	Error (%)	$\Delta f/\Delta T$ (Angular coefficient)	τ_f (ppm °C^{-1})	Error (%)	$\Delta f/\Delta T$ (Angular coefficient)
$CaTiO_3$	621.16	0.108	1.72×10^{-3}	624.32	0.088	1.18×10^{-3}
Al_2O_3	−47.38	0.015	-2.47×10^{-4}	−44.20	0.035	-1.37×10^{-4}
BTNO	—	—	—	−104.19	0.021	-2.54×10^{-4}

In conclusion a new experimental configuration to measure the temperature coefficient of resonant frequency (τ_f) in dielectric resonators was presented. The new experimental setup, to measure the τ_f value, is based on the frequency variation with the temperature of the HE_{11d} mode of a DRA. The method is quite compatible with the measurement of τ_f of the Courtney method. The obtained results by measuring the τ_f value of CTO and Al_2O_3, in this proposed method, is presenting excellent agreement when compared to the traditional Courtney method. The dielectric loss is less affected in this method and this is the most important advantage that was obtained. In the tests, the τ_f of the sample with higher loss ($>10^{-2}$) was obtained. In this case, the τ_f value for the BTNO resonator was -104.19 ppm^{o}C^{-1} . The analysis of the temperature coefficient of resonant frequency (τ_f) in dielectric

resonators is an important property for the development of high frequency electronic devices, considering that this is a fundamental parameter, for the production of new components like filters, oscillators and antennas, with high thermal stability.

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doi:10.1063/1.4755799

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Supervision of PhD Thesis

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Changes in research objectives, if any: xxxxx

Change in AFOSR program manager, if any: xxxxx

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The study of layered magneto-dielectric composites structures is important for applications at higher frequencies where the use of metals is leading to higher loss. This kind of component based in a new configuration and using a new group of magneto-dielectric composites and blends is expected to present better bandwidth, low loss, high impedance matching that will open the possibility to be used in radars, communication devices, navigation equipments, and so on.

The use of special structures based in composites and blends is important for components operating at high frequencies.

In this work the magnetic and dielectric properties of ceramic-ceramic and ceramic-polymer composites with $BiNbO_4$, $SrBi_2Nb_2O_9$ (SBN), $BaBi_4Ti_4O_{15}$ (BBT), $Na_2Nb_4O_{11}$(NNO), Sr_2CoNbO_6 (SCN), $FeNbTiO_6$, $BiFeO_3$, $CaTi_{1-X}(Nb_{1/2}Fe_{1/2})_XO_3$ and ferrites $BaFe_{12}O_{19}$ $Ba_2Co_2Fe_{12}O_{22}$ (Co_2Y) and $Y_3Fe_5O_{12}$ (YIG) was studied for RF and microwave applications.

The study of the thermal stability of magneto-dielectric composites is important for applications at the microwave band and in the millimeter and near millimeter region (100-300GHz) where the thermal stability of the resonators is fundamental.

In this presentation we will discuss

--- A study in the structural and microwave properties of the alloy matrix of $CaTi_{1-X}(Nb_{1/2}Fe_{1/2})_XO_3$

--- Ferrimagnetism and Ferroelectricity of the Composite Matrix: $SrBi_2Nb_2O_9(SBN)_X$-$BaFe_{12}0_{19}(BFO)_{100-X}$

--- A new method to measure the microwave thermal stability coefficient τ_f of materials

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HIGH THERMAL STABILITY OF MICROWAVE DIELECTRIC PROPERTIES OF $CaTi_{1-X}(Nb_{1/2}Fe_{1/2})_XO_3$ CERAMICS

In this work, we studied and discussed the structural and microwave dielectric properties of the B-site modified calcium titanate ceramics. The compounds were prepared by a new procedure in the conventional solid-state method. They were properly studied, using X-ray diffraction (XRD), Raman Scattering spectroscopy, and microwave dielectric properties. Therefore, the refinement analysis of the XRD was presented and discussed.

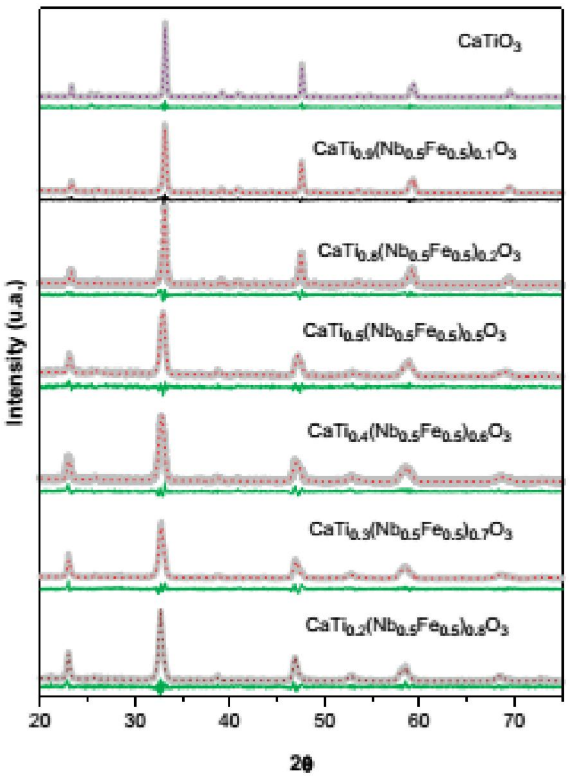

Fig. 1. XRD patterns of CTO and CNFTOX series. The dotted line is experimental pattern and the straight line is the ... ces are shown below them.

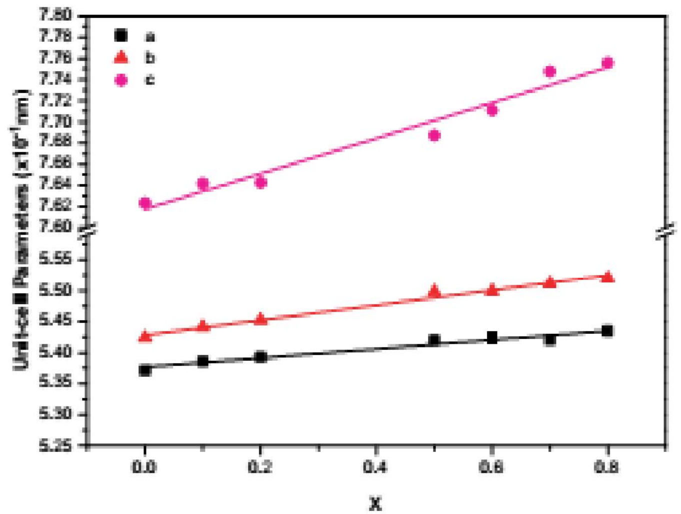

Fig. 2. Unit-cell Parameters (10^{-1} nm) for CNFTOX series.

Table 5. Microwave Dielectric Properties for samples ball-milled with ratio of 1 ball/g, calcinated at 900°C for 3 and 5 h, and sintered at 1100°C, for 3 h.

Sample	Calcination condition	f_r (GHz)	ε_r	$tg\delta$	$Q \times f$ (GHz)
CNFTO1	900°C/3h	4.451	30.42	6.4×10^{-3}	681.14
CNFTO1	900°C/5h	3.619	58.00	3×10^{-3}	1067.86
CNFTO2	900°C/3h	4.804	25.72	3×10^{-3}	1535.70
CNFTO2	900°C/5h	4.365	38.83	4×10^{-3}	979.81

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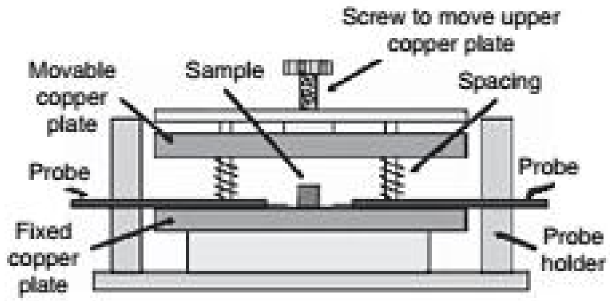

Figure 2.4 Schematic sketch of Courtney setup for measuring the dielectric constant under end shorted condition (after Ref. [12]).

Table 5. Microwave Dielectric Properties for samples ball-milled with ratio of 1 ball/g, calcinated at 900°C for 3 and 5 h, and sintered at 1100°C, for 3 h.

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Table 6. Microwave Dielectric Properties for samples calcinated at 900°C (for 5 h), and sintered at 1100°C (for 3 h).

Sample	Balls/Mass ratio	f_r (GHz)	ε_r	$tg\delta$	$Q \times f$ (GHz)
CNFTO1	1ball/g	3.619	58.00	3.0×10^{-3}	1067.86
CNFTO1	2.4balls/g	2.937	78.11	1.5×10^{-3}	1794.89
CNFTO2	1ball/g	4.365	38.83	4.0×10^{-3}	979.81
CNFTO2	2.4balls/g	3.435	56.05	9.4×10^{-3}	358.61

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The temperature coefficient of resonant frequency (τ_f) measures, the variation of the resonance frequency of the dielectric resonator with temperature variation, as seen in below equation[1,4]

$$\tau_f = \frac{1}{f_i} * \frac{\Delta f}{\Delta T} * 10^6, \qquad (1)$$

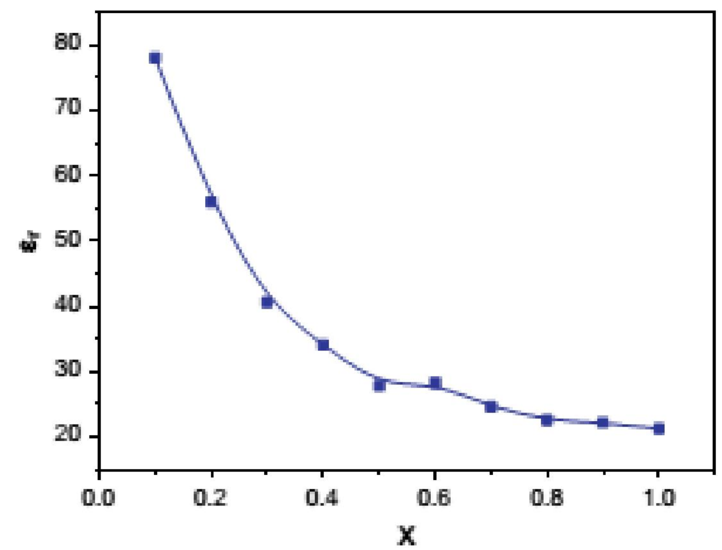

Fig. 4. Dielectric permittivity of CNFTOX ($0 \leq x \leq 1$) for ball milled samples with ball/mass ratio of 2.4, calcinated at 900°C (for 5 h), and sintered at 1100°C (for 3 h).

Table 7. Microwave Dielectric Properties for samples ball-milled with ratio of 2.4 balls/g, calcinated at 900°C (for 5 h) and sintered 1100°C, for 3 h.

Sample	f_r (GHz)	ε_r	$Tg\delta$	τ_f (ppm/°C)	$Q \times f$ (GHz)
CTO	2.659	101.33	2.1×10^{-3}	1022.909	1266.19
CNFTO1	2.937	78.11	2.3×10^{-3}	518.676	1275.65
CNFTO2	3.435	56.05	9.4×10^{-3}	422.987	365.43
CNFTO3	3.964	40.66	5.5×10^{-3}	264.635	720.73
CNFTO4	4.335	34.16	5.1×10^{-3}	412.154	850.00
CNFTO5	4.889	26.52	4.8×10^{-3}	58.478	1017.92
CNFTO6	4.831	28.35	4.2×10^{-3}	2.866	1150.24
CNFTO7	5.280	24.60	3.6×10^{-3}	−32.574	1466.94
CNFTO8	5.381	22.62	4.6×10^{-3}	−44.744	1169.78
CNFTO9	5.771	22.18	1.0×10^{-3}	−71.318	577.10
CNFO	5.723	21.28	4.8×10^{-3}	−88.231	1192.29

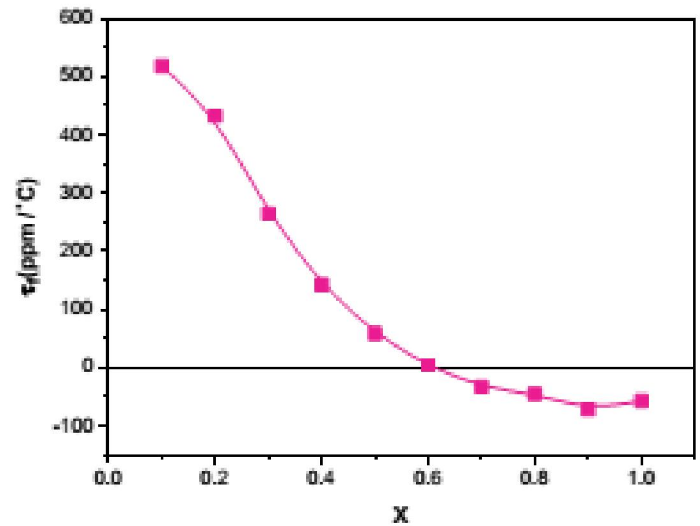

Fig. 6. τ_f of CNFTOX ($0 \leq x \leq 1$) for ball milled sample with ball/mass ratio of 2.4, calcinated at 900°C (for 5 h), and sintered at 1100°C (for 3 h).

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Results showed that the samples belong to the Pbnm spatial group.

The microwave dielectric properties of the $Ca[(Fe_{1/2}Nb_{1/2})_xTi_{1-x}]O_3$ for ball-milled samples (with ratios of 1 and 2.4 balls/g), calcinated at 900ºC (with different time of exposure – 3 and 5 h), and sintered at 1100ºC (for 3h) were investigated.

Dielectric permittivity values in the range of 20 to 80 were obtained.

Regarding the studied samples, the quality factor values increased with the decrease of the titanium substitution in the region from x = 0.2 to 0.7. Considering the increase of the x value (titanium substitution), we observe the decrease of the temperature coefficient of resonant frequency (τ_f). The CNFTO has excellent microwave properties at x = 0.6, with a temperature coefficient of resonant frequency (τ_f) almost zero (τ_f = 2.8 ppm/ºC). At x = 0.7, the τ_f values became negative and Q.f decreases.

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Ferrimagnetism and Ferroelectricity of the Composite Matrix: $SrBi_2Nb_2O_9$ $(SBN)_X$-$BaFe_{12}0_{19}(BFO)_{100-X}$

In this paper a study of the magnetic and dielectric properties of composites based on M-type barium hexaferrite BFO ($BaFe_{12}O_{19}$) and SBN ($SrBi_2Nb_2O_9$) is presented. The magneto-dielectric matrix composite $(SrBi_2Nb_2O_9)_x$ $(BaFe_{12}O_{19})_{100-x}$, (x = 0,25,50,75 and 100 wt%) were prepared by a new procedure using the solid state reaction method.

In this work, our main goal is to develop a dielectric material that is able to respond to both electric and magnetic stimulus, i.e. that is ferroelectric and ferromagnetic.

To do so, we use the Aurivillius ceramic $SrBi_2Nb_2O_9$ and the Hexaferrite $BaFe_{12}O_{19}$. Such a material could be applied in the same way that common dielectrics (as dielectric resonator antennas, for example) but opening a wide range of possibilities to make the application of ceramics to electronic devices, memories and telecommunications more useful and powerful.

$$Bi_2O_3 + Nb_2O_5 + SrCO_3 \rightarrow SrBi_2Nb_2O_9 + CO_2$$
$$BaO + 6Fe_2O_3 \rightarrow BaFe_{12}O_{19}$$

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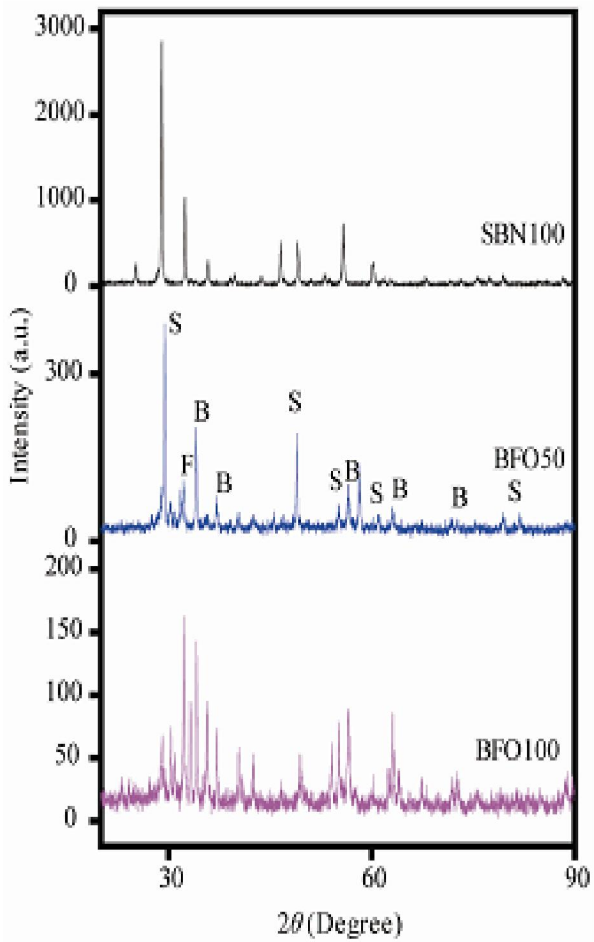

Figure 1. X-Ray diffractograms for SBN100, BFO50, BFO100 samples.

Table 1. Rietveld refinement parameters.

Sample	SBN 100	BFO100
a (nm)	0.5515	0.5868
b(nm)	0.5513	0.5868
C(nm)	2.5024	2.3106
Density (g/cm^3)	7.293	5.358
Volume (nm^3)	0.761062	0.689074
R_p	10.74%	27.43%
R_{wp}	14.7%	34.96%
R_{exp}	11.6%	22.73%
S	1.27	1.54

Table 2. Relative density of the samples obtained from the Archimedes method.

Binder	Sample	Relative Density
TEOS	BFO100 T	93.83%
	BFO75 T	83.09%
	BFO50 T	91.88%
	BFO25 T	87.19%
	SBN100 T	82.70%
PVA	BFO100 P	83.09%
	BFO75 P	80.77%
	BFO50 P	85.60%
	BFO25 P	78.11%
	SBN100 P	67.92%
Glycerin	BFO100 G	66.04%
	BFO75 G	81.02%
	BFO50 G	83.61%
	BFO25 G	83.32%
	SBN100 G	80.30%

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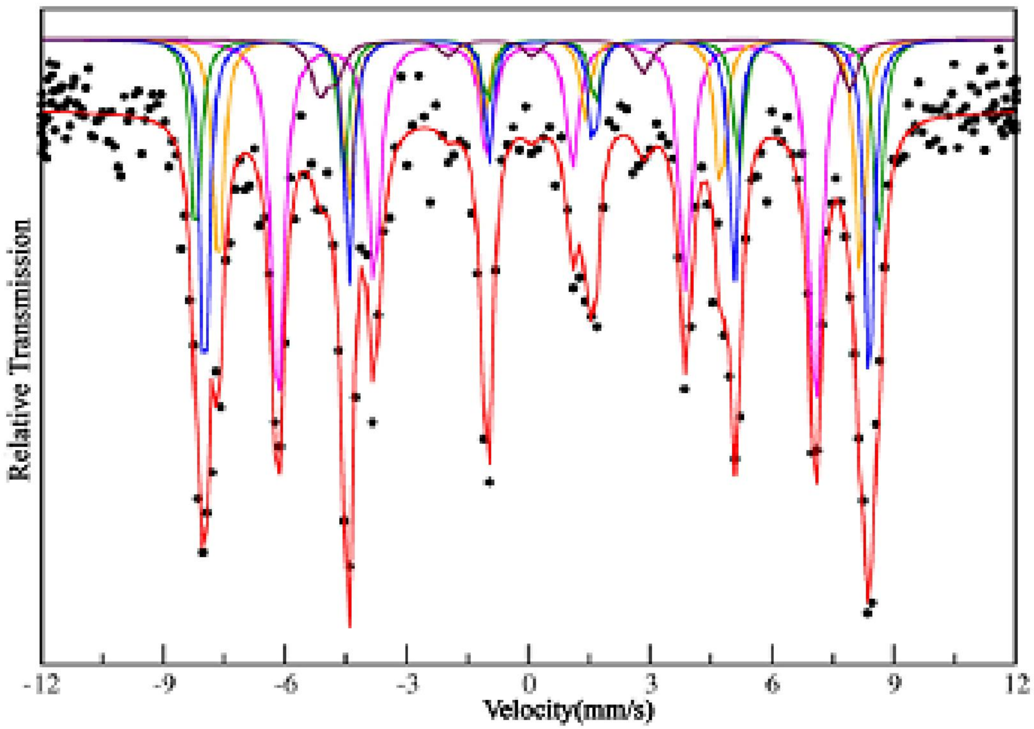

Figure 4. Mössbauer Spectrum for the BFO100 sample.

Table 3. Hyperfine parameters of the Mössbauer measurements.

Sample	Sites	Coordination	IS (mm/s)	QS (mm/s)	H_{hf} (T)	R_A (%)
	12k	octahedral	0.351	0.401	41.09	36%
	4f1	tetrahedral	0.334	0.097	49.00	18%
BFO100	4f2	octahedral	0.372	-0.099	52.16	15%
	2a	octahedral	0.371	-0.098	50.79	24%
	2b	trigonal bipyramidal	0.326	2.310	40.65	6%

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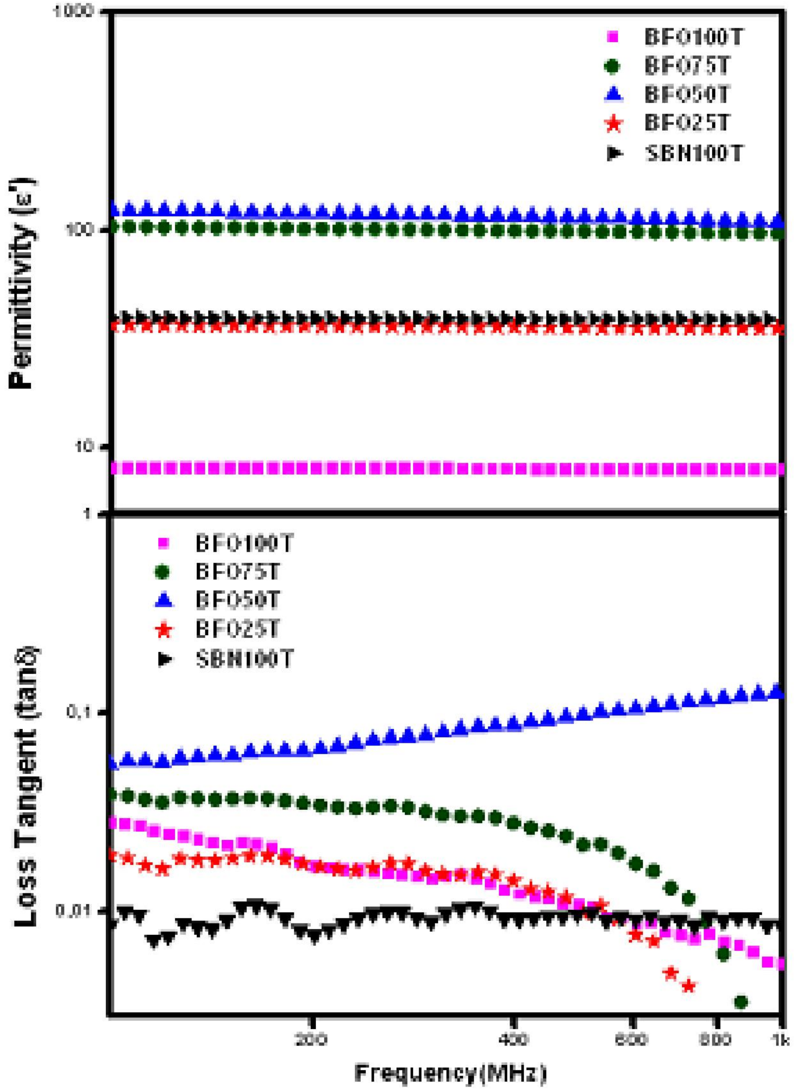

Figure 6. RF measurements of (a) Permittivity and (b) Loss tangent for TEOS samples.

Table 4. Values of permittivity and loss in the RF range.

Samples	100 MHz		500 MHz		1 GHz	
	ε'	tanδ	ε'	tanδ	ε'	tanδ
BFO 100 G	12.38	0.0072	12.58	0.02	13.15	0.040
BFO 75 G	23.17	0.0374	22.80	0.023	23.56	0.032
BFO 50 G	69.75	0.167	48.71	0.212	45.340	0.235
BFO 25 G	36.12	0.004	36.84	0.117	41.81	0.202
SBN 100 G	35.46	0.048	37.51	0.246	43.03	0.428
BFO 100 P	13.19	0.0061	13.43	0.036	14.13	0.050
BFO 75 P	77.04	0.0484	78.03	0.068	96.91	0.117
BFO 50 P	33.10	0.0854	31.07	0.0217	33.15	0.00052
BFO 25 P	42.42	0.0115	44.02	0.174	51.70	0.308
SBN 100 P	27.89	0.0037	28.03	0.0027	28.90	0.0007
BFO 100 T	8.04	0.0055	8.05	0.002	8.10	0.003
BFO 75 T	96.68	0.0046	104.8	0.238	143.3	0.490
BFO 50 T	108.94	0.128	91.44	0.231	88.94	0.282
BFO 25 T	35.35	0.0055	36.47	0.146	42.16	0.255
SBN 100 T	39.05	0.0086	39.19	0.008	41.18	0.006

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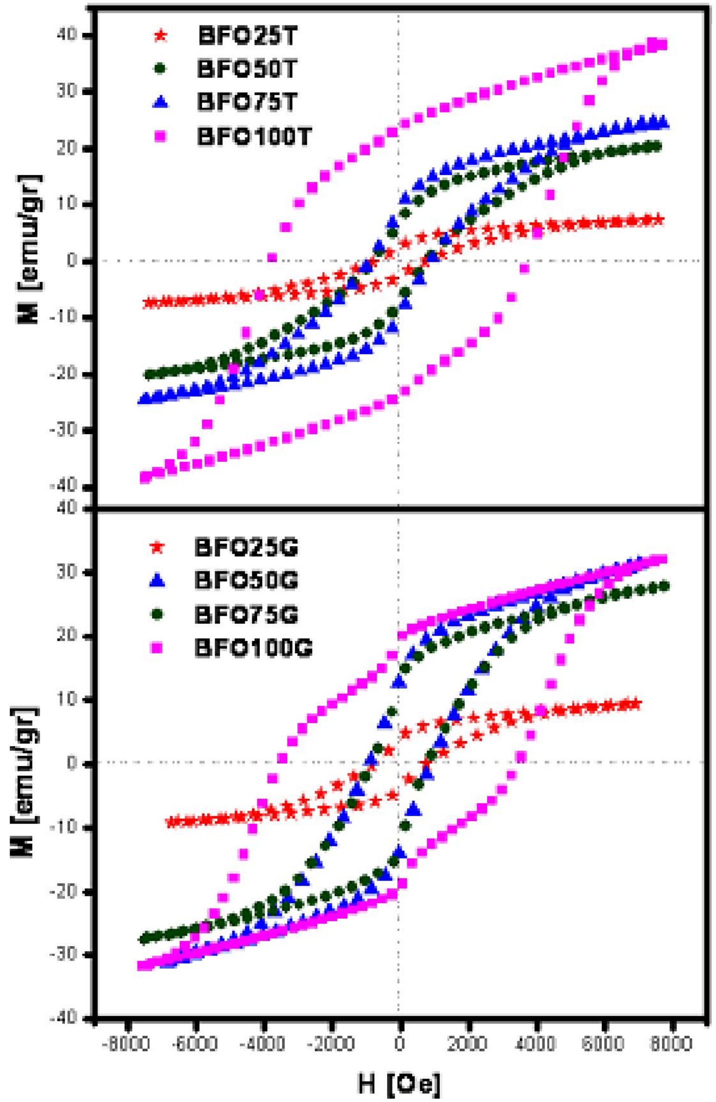

Figure 7. Magnetic hysteresis loops for (a) TEOS and (b) Glycerin samples.

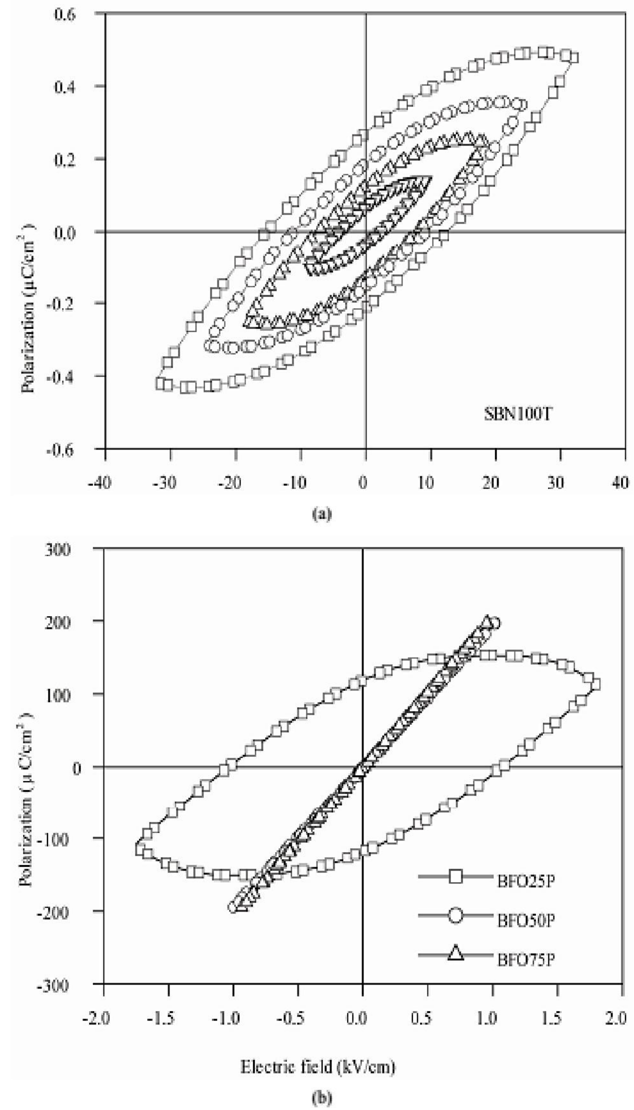

Figure 8. Electric hysteresis loops recorded at 1 Hz frequency for (a) SBN100T sample and (b) BFO25P, BFO50P and BFO75P composites.

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Table 5. Magnetic Hysteresis parameters of the samples.

Samples	Remanent Magnetization (emu/g)	Coercive Field (Oe)	Saturation Magnetization (emu/g)	Maximum Field (Oe)
BFO 100 T	23.98	3744.4	34.97	7680
BFO 75 T	10.07	932.8	20.39	7676.4
BFO 50 T	7.60	813.6	17.39	7539
BFO 25 T	2.34	725	5.99	7388
BFO 100 P	21.13	3699.4	31.33	7578
BFO 75 P	15.84	1110	27.34	7418.4
BFO 50 P	8.73	633.8	18.13	7629
BFO50 P	3.76	923	6.46	7648.6
BFO 100 G	19.99	3460.4	28.90	7692.8
BFO 75 G	13.86	833	26.24	7731.6
BFO 50 G	14.10	868	22.31	7010.4
BFO 25 G	4.01	747.4	7.33	6888.2

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Conclusions

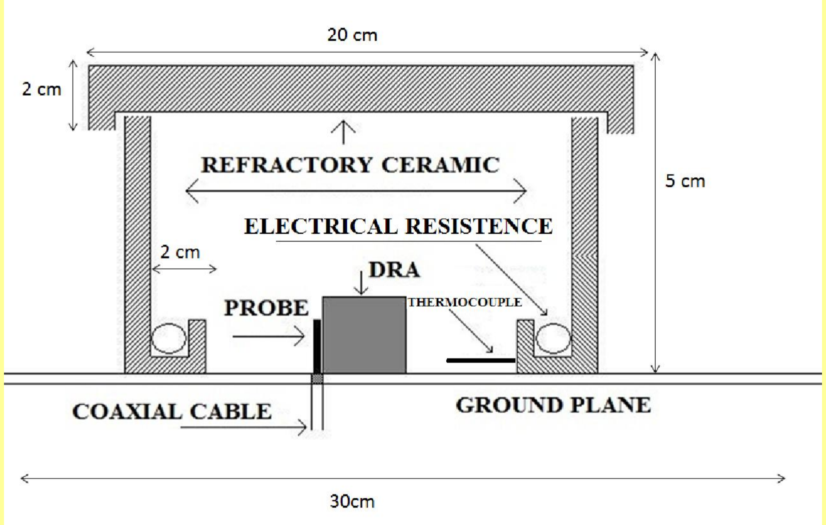
A complex behavior was observed for the loss tangent over the radio frequency range, which means that less lossy samples could not help keeping this characteristic over entire frequency range. The magnetic hysteresis loops showed that composite samples preserve the ferrimagnetism for hexaferrite when SBN is added to the composite, although they become less coercive. For electric hysteresis the density of the samples are not high enough to define the true behavior of ferroelectricity in composite samples.

For further works, the properties over microwave frequency range, thermal influences on the dielectric properties will be investigated for possible applications of the composite.

A NEW METHOD FOR THE MEASUREMENT OF THE MICROWAVE TEMPERATURE COEFFICIENT OF RESONANT FREQUENCY (τf).

A.S.B.Sombra, Federal University of Ceará – *BRAZIL*

The study of the thermal stability of magneto-dielectric composites is important for applications at the microwave band and in the millimeter and near millimeter region (100-300GHz) where the thermal stability of the resonators is fundamental.



Modified setup, for the measurement of τ_f

Objectives and Approach

A new method to measure the microwave thermal stability coefficient τ_f

$$\tau_f = \frac{1}{f_i} * \frac{\Delta f}{\Delta T} * 10^6,$$

TABLE I. $TE_{01\delta}$, $HE_{11\delta}$ e $TM_{01\delta}$ modes and dielectric parameters of CTO, Al_2O_3, and BTNO dielectrics.

	$CaTiO_3$	Al_2O_3	BTNO
a (mm)	7.48	12.70	7.31
h (mm)	8.04	12.70	7.38
a(mm)/h(mm)	0.93	1	0.99
ε_R	92.25	9.80	63.68
tan δ	5.81×10^{-4}	1.11×10^{-4}	5.61×10^{-2}
$f_{monopole}$ (GHz) measured	1.888	3.089	2.439
$f_{HE11\delta}$ (GHz) calculated	1.837	3.147	2.328
$f_{TE01\delta}$ (GHz) calculated	1.830	3.201	2.288
$f_{TM01\delta}$ (GHz) calculated	2.695	4.527	3.357

Used samples in the measurements

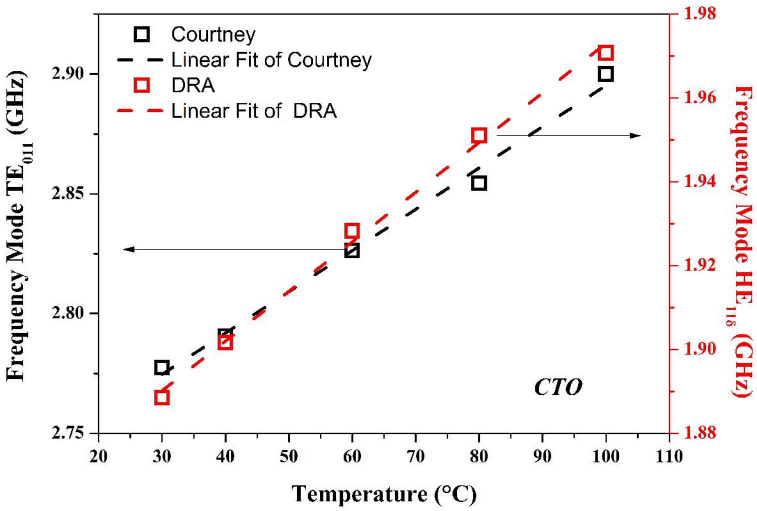


FIG. 4. Measurement of τ_f for a DRA based on CTO: □ alternative method ($HE_{11\delta}$) and ○ Courtney method (TE_{011}).

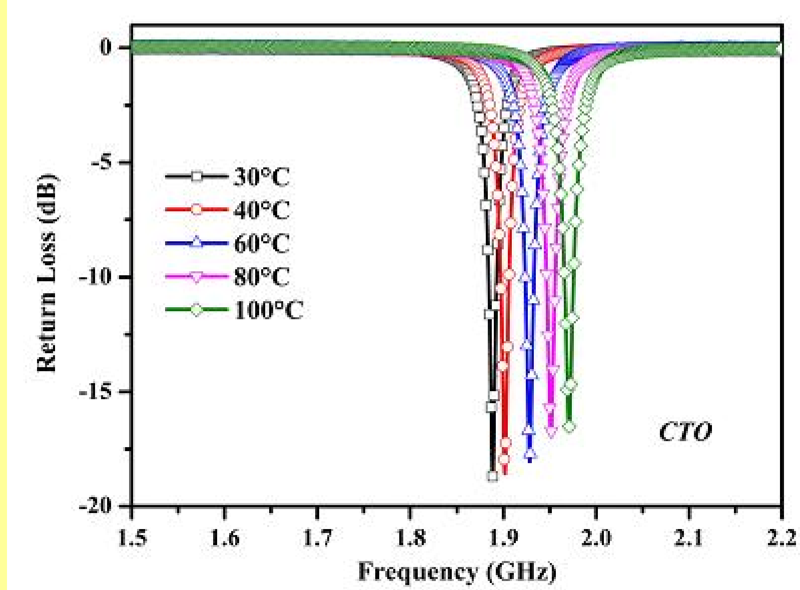


FIG. 5. Frequency variation of the $HE_{11\delta}$ mode for DRA based on CTO with increasing temperature.

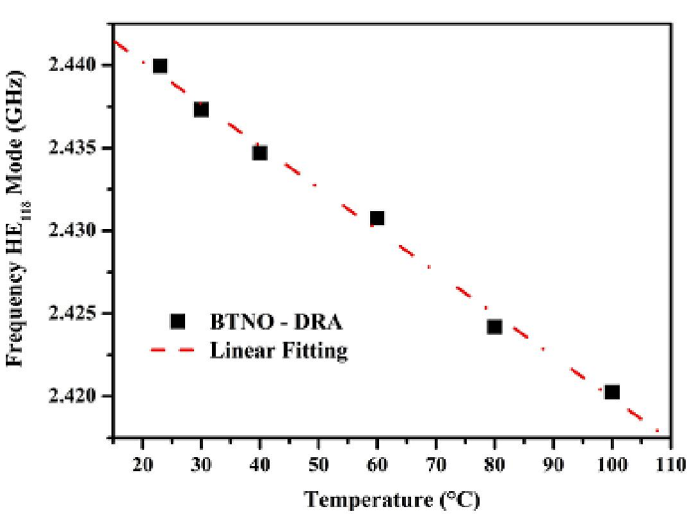


FIG. 9. Measurement of τ_f for a DRA based on BTNO by the alternative method ($HE_{11\delta}$).

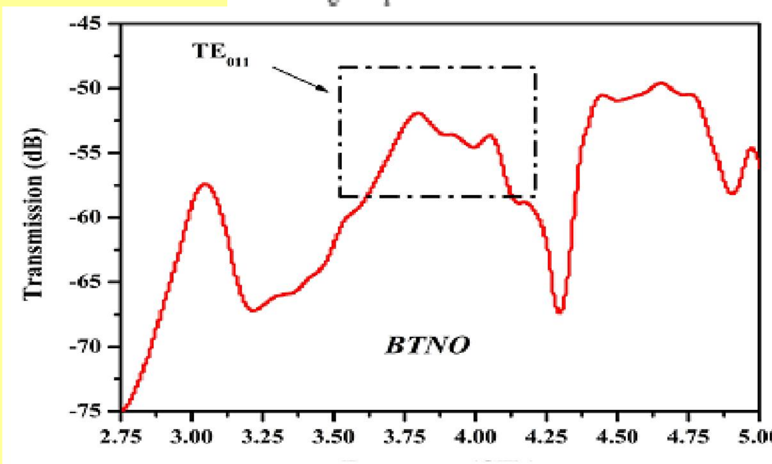


FIG. 7. Measurement of transmission by the Courtney method for the BTNO resonator.

ε_r

TABLE II. Measurements of τ_f of CTO, Al_2O_3, and BTNO from Courtney and DRA methods.

	Method					
	Courtney method			Dielectric resonator antenna		
Ceramic	τ_f (ppm °C^{-1})	Error (%)	$\Delta f/\Delta T$ (Angular coefficient)	τ_f (ppm °C^{-1})	Error (%)	$\Delta f/\Delta T$ (Angular coefficient)
$CaTiO_3$	621.16	0.108	1.72×10^{-3}	624.32	0.088	1.18×10^{-3}
Al_2O_3	−47.38	0.015	-2.47×10^{-4}	−44.20	0.035	-1.37×10^{-4}
BTNO	—	—	—	−104.19	0.021	-2.54×10^{-4}

In this work a new experimental configuration to measure the temperature coefficient of resonant frequency (τ_f) in dielectric resonators was presented. The new experimental setup, to measure the τ_f value, is based on the frequency variation with the temperature of the HE11dmode of a DRA. The method is quite compatible with the measurement of τ_f of the Courtney method. The obtained results by measuring the τ_f value of CTO and Al2O3, in this proposed method, is presenting excellent agreement when compared to the traditional Courtney method. The dielectric loss is less affected in this method and this is the most important advantage that was obtained. In the tests, the τ_f of the sample with higher loss (>10 $^{-2}$) was obtained. In this case, the τ_f value for the BTNO resonator was -104.19 ppm. C $^{-1}$. The analysis of the temperature coefficient of resonant frequency (τ_f) in dielectric resonators is an important property for the development of high frequency electronic devices, considering that this is a fundamental parameter, for the production of new components like filters, oscillators and antennas, with high thermal stability.

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M.A.S. Silva, T.S. M. Fernandes and A.S.B. Sombra
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ELECTRICAL AND STRUCTURAL PROPERTIES STUDY OF LAYERED DIELECTRIC AND MAGNETIC COMPOSITES AND BLENDS STRUCTURES FOR RF AND MICROWAVE APPLICATIONS

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Antonio sergio Bezerra Sombra

Program Manager
The AFOSR Program Manager currently assigned to the award

James Fillerup

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Abstract

In this work the magnetic and dielectric properties of ceramic-ceramic and ceramic-polymer composites with $BiNbO_4$, $SrBi_2Nb_2O_9$ (SBN), $BaBi_4Ti_4O_{15}$ (BBT), $Na_2Nb_4O_{11}$(NNO), Sr_2CoNbO_6 (SCN) and ferrites $BaFe_{12}O_{19}$ and $Y_3Fe_5O_{12}$ (YIG) was studied for RF and microwave applications. New configurations of magneto-dielectric composites and blends structures for high frequency applications was done. The 0-3 type dielectric and magnetic composites with homogenously distributed ceramic inclusions was fabricated in a polymer matrix. Magnetic Yttrium Iron Garnet (YIG) and (SBN) powders were used to enhance the permittivity and permeability of the composites. This group of dielectric and magnetic phases was studied in the RF and microwave region. The microstructure, high frequency dielectric and magnetic properties of individual layers and 2-2 composites was investigated and measured.

A new method for the measurement of the temperature coefficient of resonant frequency (τf), is presented. The traditional method (based on the Courtney method) present some limitations of measuring the values of τf , for samples with high dielectric loss due to their inability to observe clearly the TE011 mode. The new experimental setup, to measure the τf value, is based on the variation of the temperature of the dominant mode of a dielectric resonator antenna (DRA).

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10.1016/j.physb.2011.03.050
2- Impedance and Modulus Studies of Magnetic Ceramic Oxide Ba2Co2Fe12O22 (Co2Y) doped with Bi2O3 M. M Costa, G. F. M. Pires Júnior , A.J Terezo, M.P.F. Graça and
A.S.B. Sombra Journal of Applied Physics 110(3),034107 (2011)AIP
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Changes in research objectives (if any):

Change in AFOSR Program Manager, if any:

Extensions granted or milestones slipped, if any:

AFOSR LRIR Number

LRIR Title

Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, $K)

	Starting FY	FY+1	FY+2
Non-Military Government Personnel Costs			
In-house Contractor Costs			
Travel (Be Specific)			
Training (Be Specific)			
Supplies			
Other Expenses (Be Specific)			
Total Resource Requirements			

Report Document

Appendix Documents

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